

CLAIMS

1. A blur correction camera system comprising:
 - a vibration detection unit that detects a vibration and
 - 5 outputs a vibration detection signal;
 - a blur correction optical system that is driven based upon the vibration detection signal and corrects an image blur;
 - an image-capturing unit that captures an image formed with a photographic optical system that includes the blur
 - 10 correction optical system; and
 - an image restoration computing unit that corrects an image blur by executing image restoration through image processing on an image captured by the image-capturing unit.
- 15 2. A blur correction camera system according to claim 1, further comprising:
 - a point spread function computing unit that computes a point spread function, wherein:
 - the image restoration computing unit executes the image
 - 20 restoration by processing the image using the point spread function.
3. A blur correction camera system according to claim 2, further comprising:

a reference value computing unit that computes a reference value for the vibration detection signal, wherein:

the point spread function computing unit computes the point spread function based upon calculation results of the
5 reference value computing unit.

4. A blur correction camera system according to claim 3, comprising:

a camera that comprises the vibration detection unit,
10 the blur correction optical system, the image-capturing unit, the point spread function computing unit, the reference value computing unit and an image recording unit that records an image; and

an external device comprising the image restoration computing unit, that is a device independent of the camera and executes the image restoration by using the image recorded by the image recording unit and the point spread function input thereto.

20 5. A blur correction camera comprising:

a vibration detection unit that detects a vibration and outputs a vibration detection signal;

a blur correction optical system that is driven based upon the vibration detection signal and corrects an image blur;

an image-capturing unit that captures an image formed by a photographic optical system that includes the blur correction optical system;

5 an image recording unit that records the image captured by the image-capturing unit; and

 a point spread function computing unit that computes a point spread function needed in image restoration computation.

10 6. A blur correction camera according to claim 5, further comprising:

 a point spread function output means for outputting the point spread function computed by the point spread function computing unit to an outside by utilizing one of the image 15 recording unit and a communication means.

7. A blur correction camera according to claim 5 or claim 6, further comprising:

20 a reference value computing unit that computes a reference value for the vibration detection signal, wherein:

 the point spread function computing unit computes the point spread function based upon calculation results of the reference value computing unit.

25 8. An image restoring device comprising:

a data input unit that receives image data and a point spread function obtained when capturing the image data through at least one of communication with an outside and a medium; and

5 an image restoration computing unit that executes an image restoration so as to correct an image blur by executing image processing on the image data using the point spread function.

10 9. A computer readable computer program product containing a blur correction control program, the control program comprising:

15 a data input instruction for receiving image data and a point spread function obtained when capturing the image data; and

an image restoration computation instruction for executing image restoration so as to correct an image blur by executing image processing on the image data using the point spread function.

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10. A computer program product according to claim 9, wherein:
the computer program product is a recording medium on which the control program is recorded.

25 11. A computer program product according to claim 9, wherein:

the computer program product is a carrier wave on which
the control program is embodied as a data signal.

12. A blur correction camera system comprising:

- 5 a vibration detection unit that detects a vibration and outputs a vibration detection signal;
- a reference value computing unit that computes a reference value for the vibration detection signal;
- a blur correction optical system that is driven based upon the vibration detection signal and the reference value and corrects an image blur;
- an image-capturing unit that captures an image formed with a photographic optical system that includes the blur correction optical system;
- 15 a point spread function computing unit that computes a point spread function by using one of the reference value and the vibration detection signal; and
- an image restoration computing unit that corrects an image blur by executing image restoration through image processing on an image captured by the image-capturing unit using the point spread function.

13. A blur correction camera system according to claim 12,
further comprising:

a point spread function computation switching unit that selects one of the reference value and the vibration detection signal to be used in the computation of the point spread function executed by the point spread function computing unit.

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14. A blur correction camera system according to claim 13, wherein:

the point spread function computation switching unit also functions as a blur correcting operation setting unit 10 that switches on/off a blur correcting operation by the blur correction optical system.

15. A blur correction camera system according to any one of claims 12 through 14, wherein:

15 when the blur correcting operation is to be executed by the blur correction optical system, the point spread function computing unit computes the point spread function by using the reference value.

20 16. A blur correction camera system according to any one of claims 12 through 14, wherein:

if the blur correction optical system is not to be engaged in a blur correcting operation, the point spread function computing unit computes the point spread function by using 25 the vibration detection signal.

17. A blur correction camera system according to claim 12,
comprising:

a camera that comprises the vibration detection unit,
5 the blur correction optical system, the image-capturing unit,
the point spread function computing unit, the reference value
computing unit and an image recording unit that records an
image; and

an external device comprising the image restoration
10 computing unit, that is a device independent of the camera
and executes the image restoration by using the image recorded
by the image recording unit and the point spread function input
thereto.

15 18. A blur correction camera comprising:

a vibration detection unit that detects a vibration and
outputs a vibration detection signal;

a reference value computing unit that computes a
reference value for the vibration detection signal;

20 a blur correction optical system that is driven based
upon the vibration detection signal and the reference value
and corrects an image blur;

an image-capturing unit that captures an image formed
by a photographic optical system that includes the blur
25 correction optical system;

an image recording unit that records the image captured by the image-capturing unit; and

a point spread function computing unit that computes a point spread function by using one of the reference value
5 and the vibration detection signal.

19. A blur correction camera according to claim 18, further comprising:

a point spread function output means for outputting to
10 an outside the point spread function computed by the point spread function computing unit by utilizing one of the image recording unit and a communication means.

20. A blur correction camera comprising:

15 a vibration detection unit that detects a vibration and outputs a vibration detection signal;

a reference value computing unit that computes a reference value for the vibration detection signal;

a blur correction optical system that is driven based
20 upon the reference value and the vibration detection signal and corrects an image blur;

an image-capturing unit that captures an image formed by a photographic optical system that includes the blur correction optical system;

a point spread function computing unit that computes a point spread function needed in an image restoration computation based upon the reference value; and

an information volume reducing unit that reduces a volume
5 of information related to at least one of the reference value used in the computation of the point spread function and the computed point spread function.

21. A blur correction camera according to claim 20, wherein:

10 the information volume reducing unit reduces the information volume by culling data related to at least one of the reference value and the computed point spread function.

22. A blur correction camera according to claim 20 or claim

15 21, wherein:

the information volume reducing unit reduces the information volume by ensuring that there will still be a large enough volume of information required for the image restoration computation.

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23. A blur correction camera system comprising:

a vibration detection unit that detects a vibration and outputs a vibration detection signal;

- an image-capturing unit that captures an image formed by a photographic optical system that includes a blur correction optical system as a raw image;
- an raw image saving unit that saves the raw image;
- 5 an image restoration computing unit that allows parameters related to image processing to be varied, executes image restoration through image processing on the raw image by using the parameter and creates a restored image obtained by correcting an image blur; and
- 10 a restoration result saving unit that saves at least one of the parameters used in the image processing executed at the image restoration computing unit and the restored image in correspondence to the raw image.
- 15 24. A blur correction camera system according to claim 23, further comprising:
- a point spread function computing unit that computes a point spread function, wherein:
- the image restoration computing unit executes the image
- 20 restoration by processing the image using the point spread function; and
- the parameters include the point spread function.
25. A blur correction camera system according to claim 23 or claim 24, wherein:

the restoration result saving unit is capable of saving at least one of a plurality of sets of parameters each corresponding to one of a plurality of restored images and the plurality of restored images.

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26. A blur correction camera system according to claim 24, comprising:

a camera that comprises the vibration detection unit; the blur correction optical system that is driven based upon the vibration detection signal and corrects an image blur, the image-capturing unit, the point spread function computing unit, a reference value computing unit that computes a reference value for the vibration detection signal and the raw image saving unit; and

an external device comprising the image restoration computing unit and the restoration result saving unit, that is a device independent of the camera and executes image restoration by using the raw image recorded at the raw image saving unit and the point spread function input thereto.

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27. An image restoring device comprising:

a data input unit that receives raw image data and a point spread function obtained when capturing the raw image data through at least one of communication with an external device and a medium;

an image restoration computing unit that allows a parameter related to image processing to be varied, executes image restoration through executing image processing on the raw image data using parameters that include the point spread function and creates a restored image obtained by correcting an image blur; and

a restoration result saving unit that saves at least one of the parameters used in the image processing executed by the image restoration computing unit and the restored image in correspondence to the raw image.

28. A computer readable computer program product containing a blur correction control program, the control program comprising:

a data input instruction for receiving raw image data and a point spread function obtained when capturing the raw image data;

an image restoration computation instruction for creating a restored image by executing image restoration so as to correct an image blur through image processing executed on the raw image data using variable parameters related to the image processing that include the point spread function; and

a restoration result saving instruction for saving at least one of the parameters used in the image processing during

the image restoration computation step and the restored image in correspondence to the raw image data.

29. A computer program product according to claim 28,
5 wherein:

the computer program product is a recording medium on which the control program is recorded.

30. A computer program product according to claim 28,
10 wherein:

the computer program product is a carrier wave on which the control program is embodied as a data signal.

31. A blur correction camera comprising:

15 a vibration detection unit that detects a vibration and outputs a vibration detection signal;

an optical blur correction means for correcting an image blur by driving a blur correction optical system based upon the vibration detection signal;

20 a point spread function computing unit that computes a point spread function needed in image restoration in which the image blur is corrected through image processing; and

an image restoration decision-making unit that makes a decision as to whether to enter an image restoration mode
25 in which blur correction is executed through the image

restoration or a preparatory operation for blur correction to be achieved through the image restoration is executed.

32. A blur correction camera according to claim 31, wherein:

5 the image restoration decision-making unit makes a decision as to whether to enter the image restoration mode based upon the vibration detection signal.

33. A blur correction camera according to claim 31 or claim 10 32, wherein:

the image restoration decision-making unit makes a decision as to whether to enter the image restoration mode based upon a shutter speed.

15 34. A blur correction camera according to any one of claims 31 through claim 33, wherein:

the image restoration decision-making unit makes a decision as to whether to enter the image restoration mode based upon a focal length of a photographic optical system.

20 35. A blur correction camera according to claim 31, wherein:

the image restoration decision-making unit makes a decision as to whether to enter the image restoration mode based upon the point spread function.

36. A blur correction camera according to any one of claims
31 through claim 35, further comprising:

a reporting means for reporting a decision made by the
image restoration decision-making unit that the image
restoration mode should not be entered.

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37. A blur correction camera according to any one of claims
31 through claim 36, wherein:

if the image restoration decision-making unit
10 determines that the image restoration mode should not be
entered, the image restoration mode is not entered.

38. A blur correction camera according to any one of claims
31 through claim 37, wherein:

15 if the image restoration decision-making unit
determines that the image restoration mode should not be
entered, the point spread function is not saved.

39. A blur correction camera comprising:

20 a vibration detection unit that detects a vibration and
outputs a vibration detection signal;

a reference value computing unit that computes a
reference value for the vibration detection signal;

a blur correction optical system that is driven based upon the reference value and the vibration detection signal and corrects an image blur;

5 a drive control unit that controls an operation of the blur correction optical system based upon the vibration detection signal and the reference value;

10 a point spread function computing unit that computes based upon the reference value a point spread function needed in an image restoration executed to correct an image blur through image processing; and

15 a blur correction mode selection unit that selects whether to enter an image restoration mode in which a blur correction is executed through the image restoration or a preparatory operation for blur correction to be achieved through the image restoration is executed in addition to an optical blur correcting operation executed by engaging the blur correction optical system, wherein:

20 the drive control unit modifies the contents of control implemented on the blur correction optical system in correspondence to a selection made by the blur correction mode selection unit.

40. A blur correction camera according to claim 39, wherein:

25 the drive control unit modifies the contents of the control implemented on the blur correction optical system by

adjusting a method for reference value computation in correspondence to the selection made by the blur correction mode selection unit.

5 41. A blur correction camera according to claim 39 or claim 40, wherein:

the reference value computing unit computes the reference value by using a low pass filter; and

10 the drive control unit modifies the contents of the control implemented on the blur correction optical system by adjusting a cutoff frequency of the low pass filter.

42. A blur correction camera according to claim 41, wherein:

15 if the selection made by the blur correction mode selection unit indicates that image restoration is to be executed, the drive control unit sets the cutoff frequency to a higher level than the cutoff frequency set when the selection made by the blur correction mode selection unit indicates that image restoration is not to be executed.

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43. A blur correction camera comprising:

a vibration detection unit that detects a vibration and outputs a vibration detection signal;

an optical blur correction means for correcting an image blur by driving a blur correction optical system based upon the vibration detection signal;

a point spread function computing unit that computes
5 a point spread function needed in image restoration executed to correct through image processing a blur that cannot be completely corrected by the optical blur correction means; and

a blur correction mode selection unit that selects an
10 optical blur correction mode in which blur correction is executed by engaging the optical blur correction means in operation and an image restoration mode in which blur correction is executed through image restoration or a preparatory operation for blur correction to be achieved
15 through image restoration is executed, wherein:

when the blur correction mode selection unit selects the image restoration mode, the optical blur correction mode is also selected by the blur correction mode selection unit.

20 44. A blur correction camera comprising:

a vibration detection unit that detects a vibration and outputs a vibration detection signal;

an optical blur correction means for correcting an image blur by driving a blur correction optical system based upon
25 the vibration detection signal;

a point spread function computing unit that computes a point spread function needed in image restoration executed to correct through image processing a blur that cannot be completely corrected by the optical blur correction means;

5 and

a blur correction mode selection unit that selects an optical blur correction mode in which blur correction is executed by engaging the optical blur correction means in operation and an image restoration mode in which blur 10 correction is executed through image restoration or a preparatory operation for blur correction to be achieved through image restoration is executed, wherein:

the blur correction mode selection unit is not allowed to select the image restoration mode unless the optical blur 15 correction mode is also selected.

45. A blur correction camera comprising:

a vibration detection unit that detects a vibration and outputs a vibration detection signal;

20 an optical blur correction means for correcting an image blur by driving a blur correction optical system based upon the vibration detection signal;

a point spread function computing unit that computes a point spread function needed in image restoration executed 25 to correct through image processing a blur that cannot be

completely corrected by the optical blur correction means;
and

a blur correction mode selection unit that selects an
optical blur correction mode in which blur correction is
executed by engaging the optical blur correction means in
operation and an image restoration mode in which blur
correction is executed through image restoration or a
preparatory operation for blur correction to be achieved
through image restoration is executed, wherein:

the blur correction mode selection unit issues a warning
if the image restoration mode alone is selected without also
selecting the optical blur correction mode.

46. A blur correction camera comprising:

a vibration detection unit that detects a vibration and
outputs a vibration detection signal;

an optical blur correction means for correcting an image
blur by driving a blur correction optical system based upon
the vibration detection signal; and

a point spread function computing unit that computes
a point spread function needed in image restoration executed
to correct through image processing a blur that cannot be
completely corrected by the optical blur correction, wherein:

the point spread function computing unit is enabled to execute computation of the point spread function as the optical blur correction means is engaged in operation.

- 5 47. A blur correction camera system comprising:
 - a blur correction optical system that corrects an image blur;
 - a vibration detection unit that detects a vibration and outputs a vibration signal;
 - 10 a reference value computing unit that computes a reference value for the vibration signal;
 - a drive unit that drives the blur correction optical system;
 - 15 a position detection unit that detects a position of the blur correction optical system and outputs a position signal;
 - a control unit that controls drive of the blur correction optical system based upon the reference value, the vibration signal and the position signal so as to correct a blur manifesting in a subject image due to the vibration;
 - 20 an image-capturing unit that captures an image formed by a photographic optical system that includes the blur correction optical system;
 - a control position error output unit that outputs as a control position error a difference between a target drive
- 25

position for the drive of the blur correction optical system by the control unit and an actual drive position of the blur correction optical system output by the position detection unit; and

5 an image restoration computing unit that corrects an image blur by executing image restoration on the image captured by the image-capturing unit through image processing in which the control position error is taken into consideration.

10 48. A blur correction camera system according to claim 47, further comprising:

 a point spread function computing unit that computes a point spread function needed in image restoration computation; and

15 a function correcting unit that corrects the point spread function by using the control position error, wherein:

 the image restoration computing unit executes the image restoration by executing the image processing using the point spread function having been corrected by the function correcting unit.

20 49. A blur correction camera system according to claim 47, further comprising:

a point spread function computing unit that computes a point spread function needed in image restoration computation, wherein:

the point spread function is computed based upon one
5 of (a) the reference value and the control position error,
(b) the vibration signal and the control position error, (c)
the reference value, the vibration signal and the control
position error and (d) the control position error; and

the image restoration computing unit executes the image
10 restoration by using the point spread function in the image
processing.

50. A blur correction camera system according to claim 48
or claim 49, comprising:

15 a camera that comprises at least the vibration function
unit, the blur correction optical system, the image-capturing
unit, the point spread function computing unit, the reference
value computing unit and an image recording unit that records
an image; and

20 an external device comprising at least the image
restoration computing unit, that is a device independent of
the camera and executes the image restoration using the image
recorded by the image recording unit and the point spread
function input thereto.

51. A blur correction camera system according to claim 48 or claim 49, comprising:

a camera that comprises at least the vibration function unit, the blur correction optical system, the image-capturing unit, the reference value computing unit and an image recording unit that records an image; and

an external device comprising at least the point spread function computing unit and the image restoration computing unit, that is a device independent of the camera and executes the image restoration using the image recorded by the image recording unit and an point spread function input thereto.

52. A blur correction camera comprising:

a blur correction optical system that corrects an image blur;

a vibration detection unit that detects a vibration and outputs a vibration signal;

a reference value computing unit that computes a reference value for the vibration signal;

20 a drive unit that drives the blur correction optical system;

a position detection unit that detects a position of the blur correction optical system and outputs a position signal;

- a control unit that controls drive of the blur correction optical system based upon the reference value, the vibration signal and the position signal so as to correct a blur manifesting in a subject image due to the vibration;
- 5 an image-capturing unit that captures an image formed by a photographic optical system that includes the blur correction optical system;
- an image recording unit that records an image;
- a control position error output unit that outputs as
- 10 a control position error a difference between a target drive position for the drive of the blur correction optical system by the control unit and an actual drive position of the blur correction optical system output by the position detection unit;
- 15 a point spread function computing unit that computes a point spread function needed in image restoration computation;
- a function correcting unit that corrects the point spread function by using the control position error; and
- 20 an external output means for outputting to an external device the point spread function having been corrected by the correcting unit via one of the image recording unit and a communication means.
- 25 53. A blur correction camera comprising:

a blur correction optical system that corrects an image blur;

a vibration detection unit that detects a vibration and outputs a vibration signal;

5 a reference value computing unit that computes a reference value for the vibration signal;

a drive unit that drives the blur correction optical system;

10 a position detection unit that detects a position of the blur correction optical system and outputs a position signal;

a control unit that controls drive of the blur correction optical system based upon the reference value, the vibration signal and the position signal so as to correct a blur 15 manifesting in a subject image due to the vibration;

an image-capturing unit that captures an image formed by a photographic optical system that includes the blur correction optical system;

an image recording unit that records an image;

20 a control position error output unit that outputs as a control position error a difference between a target drive position for the drive of the blur correction optical system by the control unit and an actual drive position of the blur correction optical system output by the position detection 25 unit;

a point spread function computing unit that computes a point spread function needed in image restoration computation; and

an external output means for outputting to an external
5 device the point spread function via one of the image recording unit and a communication means, wherein:

the point spread function is computed based upon one of (a) the reference value and the control position error, (b) the vibration signal and the control position error, (c) 10 the reference value, the vibration signal and the control position error and (d) the control position error.

54. A blur correction camera comprising:

a blur correction optical system that corrects an image
15 blur;
a vibration detection unit that detects a vibration and outputs a vibration signal;
a reference value computing unit that computes a reference value for the vibration signal;
20 a drive unit that drives the blur correction optical system;

a position detection unit that detects a position of the blur correction optical system and outputs a position signal;

a control unit that controls drive of the blur correction optical system based upon the reference value, the vibration signal and the position signal so as to correct a blur manifesting in a subject image due to the vibration;

5 an image-capturing unit that captures an image formed by a photographic optical system that includes the blur correction optical system;

 an image recording unit that records an image;

10 a control position error output unit that outputs as a control position error a difference between a target drive position for the drive of the blur correction optical system by the control unit and an actual drive position of the blur correction optical system output by the position detection unit; and

15 an external output means for outputting to an external device the control position error via one of the image recording unit and a communication means.

55. An image restoring device comprising:

20 a data input unit that receives through at least one of communication with an external device and a medium a control position error determined based upon a difference between a target drive position for a blur correction optical system and an actual drive position of the blur correction optical

system output by a position detection unit, image data and a point spread function obtained when capturing the image data; a function correcting unit that corrects the point spread function by using the control position error; and

5 an image restoration computing unit that corrects an image blur by executing image restoration on the image data through image processing in which the point spread function having been corrected by the function correcting unit is used.

10 56. An image restoring device comprising:

 a data input unit that receives through at least one of communication with an external device and a medium a control position error determined based upon a difference between a target drive position for a blur correction optical system

15 and an actual drive position of the blur correction optical system output by a position detection unit, image data and a vibration signal obtained when capturing the image data;

 a point spread function computing unit that computes a point spread function needed in image restoration

20 computation;

 a function correcting unit that corrects the point spread function by using the control position error; and

 an image restoration computing unit that corrects an image blur by executing image restoration on the image data

through image processing in which the point spread function having been corrected by the function correcting unit is used.

57. An image restoring device comprising:

5 a data input unit that receives, through at least one of communication with an external device and a medium, at least one of a control position error determined based upon a difference between a target drive position for a blur correction optical system and an actual drive position of the
10 blur correction optical system output by a position detection unit, image data and a vibration signal obtained when capturing the image data;

15 a point spread function computing unit that computes a point spread function needed in image restoration computation; and

an image restoration computing unit that corrects an image blur by executing image restoration on the image data through image processing in which the point spread function is used, wherein:

20 the point spread function is computed based upon one of (a) a reference value determined based upon the vibration signal and the control position error, (b) the vibration signal and the control position error, (c) the reference value, the vibration signal and the control position error and (d) the
25 control position error.

58. A computer readable computer program product comprising a blur correction control program, the control program comprising:

5 a data input instruction for receiving, through at least one of communication with an external device and a medium, a control position error determined based upon a difference between a target drive position for a blur correction optical system and an actual drive position of the blur correction 10 optical system output from a position detection unit, image data and a point spread function obtained when capturing the image data;

 a function correction instruction for correcting the point spread function by using the control position error;

15 and

 an image restoration computation instruction for correcting an image blur by executing image restoration on the image data through image processing in which the point spread function having been corrected through the function 20 correction step is used.

59. A computer readable computer program product comprising a blur correction control program, the control program comprising:

5 a data input instruction for receiving, through at least one of communication with an external device and a medium, a control position error determined based upon a difference between a target drive position for a blur correction optical system and an actual drive position of the blur correction optical system output from a position detection unit, image data and a vibration signal obtained while capturing the image data;

10 a point spread function computation instruction for computing a point spread function needed in image restoration computation;

15 a function correction instruction for correcting the point spread function by using the control position error; and

20 an image restoration computation instruction for correcting an image blur by executing image restoration on the image data through image processing in which the point spread function having been corrected through the function correction step is used.

25 60. A computer readable computer program product comprising a blur correction control program, the control program comprising:

25 a data input instruction for receiving, through at least one of communication with an external device and a medium,

at least one of a control position error determined based upon
a difference between a target drive position for a blur
correction optical system and an actual drive position of the
blur correction optical system output from a position detection
5 unit, image data and a vibration signal obtained while
capturing the image data;

a point spread function computation instruction for
computing a point spread function needed in image restoration
computation based upon one of (a) a reference value determined
10 based upon the vibration signal and the control position error,
(b) the vibration signal and the control position error, (c)
the reference value, the vibration signal and the control
position error and (d) the control position error; and

an image restoration computation instruction for
15 correcting an image blur by executing image restoration on
the image data through image processing in which the point
spread function is used.

61. A computer program product according to any one of claims
20 58 through 60, wherein:

the computer program product is a recording medium on
which the control program is recorded.

62. A computer program product according to any one of claims
25 58 through 60, wherein:

the computer program product is a carrier wave on which
the control program is embodied as a data signal.